Evaluating the performance of the reanalyzed ERA-Interim database in temporal-spatial distribution and wind speed trend in eastern Iran

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Extended abstract

Introduction

Wind is the horizontal displacement of air, under one meter per second of speed. It is a dynamic phenomenon with three main characteristics: intensity, direction, and frequency. Therefore, good knowledge of its characteristics in every area of importance is quite remarkable. For instance, while the impact of global warming on temperature and precipitation at global level over the past decades, have been considered in many studies, little attention has been dedicated to wind speed and its influence on climate change. Wind speed alterations can affect the energy of storms, shipping industries, soil moisture, evaporation, and water resources. It may even influence the evolution of dry and semi-arid environments. Furthermore, a lot of research on wind and meteorology has shown that the performance of wind turbines is sensitive to climate change. Possible changes to future wind regimes have been widely considered under changing weather conditions and due to global warming, the intensity and frequency of wind events are expected to alter at the end of this century.

Materials and Methods

The study area in this research on the eastern strip of Iran included four provinces of Khorasan Razavi, South Khorasan, Kerman, and Sistan and Baluchestan. The study used wind speed data in an altitude of 10 meters at 10 synoptic stations. It was provided with daily statistical information between 1985 and 2015, i.e. 30 years of data. When choosing this station, in addition to proper distribution within the region, an attempt was made to select more stations than the one, affected by the 120-day winds of Sistan. The study also employed 10-meter-high wind speed data of the ERA-Interim version with a resolution of 0.125 × 0.125 degrees on a

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daily basis between 1980 and 2015. For the study area, as many as 3772 pixels with an inter-pixel distance of about 12.5 km were obtained and to evaluate the performance of simulated data against observational data, several indicators were used from the Root-Mean Square Error (RMSE), Mean Bias Error (MBE), Mean Absolute Error (MAE), and the coefficient of determination (R2). It made use of non-parametric Man-Kendall method to order to investigate the trend of wind speed changes.

Results and Discussion

The ECMWF ERA-Interim version delivers a high and good performance for wind speed. Results showed that the output of the mentioned base in all studied stations was on average between 0.722 and 0.984. RMSE, MBE, and MAE characteristics in Zahedan, Khash, and Saravan stations were below 1 m/s. In other words, the wind speed of ECMWF base in these three stations had the highest performance of all 11 stations studied. The monthly statistical assessment of wind speed in the selected stations in eastern Iran during the statistical period (1985-2015) demonstrated that the average wind speed was 3.56 m/s. The correlation between wind speed with negative altitude and positive longitude was significant at the level of 0.05. Also, the relation between latitude and wind speed showed it to be negative during the cold months of the year and positive during the warm ones. The average wind speed fluctuated significantly during the 30-year statistical period, varying between 2.82 and 4.57 m/s. The minimum and maximum wind speeds occurred in December and July, respectively. The average 30-year wind speed at selected stations in eastern Iran turned out to be 2 m/s. The maximum wind speed in eastern Iran displayed many fluctuations, with autumn showing the lowest statistical value of maximum wind speed. In December, this value was 3.98 m/s. The maximum wind speed increased during all studied months. All studied months proved to be statistically significant, except for January, which though increasing was not remarkable at 0.05 and 0.01 levels. Other wind speed studies showed a significant incremental trend at $\alpha = 0.01$. The average wind speed in the study area was negative in 7 months (i.e., January, April, May, July, August, October, and December) of the year and positive in 5 months (i.e., February, March, June, September, and November) of the other. The maximum wind speed belonged to January (with 4.42 m/s), February (4.86 m/s), and March (with 5.02 m/s.) The next area in the form of a fertile one in winter, Zabol, was also the center of Iran's borders with Afghanistan, near the borderlines of South Khorasan Province. Here, the wind speed trend was positive at the time of 120-day wind onset (June with 0.79), and negative at the time of its termination (October with -0.15).

Conclusion

The average wind speed in the study area (Khorasan Razavi, South Khorasan, Kerman, and Sistan and Baluchestan Provinces) during the long-term statistical period of 30 years (from 1985 to 2015) was 3.56 m/s. The minimum and maximum wind speeds occurred in July and December, respectively. The reason for this increase in wind speed in July was due to the 120-day wind activity in Sistan, which started in June. The average wind speed in the study area was negative in 7 months (January, April, May, July, August, October, and December) of the year and positive in 5 months (February, March, June, September, and November). Investigating wind speed process via non-parametric Man-Kendall (M-K) test showed that the wind speed trend in eastern Iran in the first month of June (June) 120-day winds showed an increasing trend

(Z score of the Man-Kendall test 0.795), while in the last month (October) it decreased (-0.1152). Also, in July, when the wind speed was maximum, the average trend in the study area, having a Z score of 0.242, began declining. Pearson correlation test showed that the relation between wind speed and topography in the study area was statistically significant at 0.05. In contrast, the relation between longitude and wind speed was remarkable in all studied moles at an alpha level of 0.05, while neither the longitude nor the altitude in the study area did not show a uniform relation between latitude and wind speed. While this relation was exactly so during the warm months of the year, it was vice versa during the cold ones. In October alone, the relation between wind speed and latitude was not significant.

Keywords: Climatic Database, Mann-Kendall Test, the 120-Day Wind, Southeastern Iran.

Analysis of Equilibrium Response of Damghan Area Rivers to Tectonic and Erosion Processes Using SPL Model

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Extended Abstract

Introduction

Landforms and their response to environmental changes are among the most interesting topics of geomorphologists. One of the landforms that is most affected by tectonic and erosion processes is the rivers. They respond to tectonic processes that increase the height of landscapes and erosion processes, trying to reduce the landforms' height. This reaction can be well studied by analyzing the longitudinal profile of the rivers. One of the effective parameters in the study of tectonic and erosional status of regions is steepness and concavity, two parameters which could be examined in form of Stream Power Law (SPL). The function is related to the incision power of streams, giving a relation between slope and drainage area of the river in a logarithmic plot based on power regression, value extracts of the two parameters, and the channel's steepness and concavity. In fact experimental studies by other researchers have shown that there is a direct correlation between steepness and concavity of rivers and tectonic – erosive processes in the regions.

It is generally accepted that steep landscapes are associated with areas of high uplift rate and active tectonic. River systems are well adopted to tectonic processes to provide useful information about the rate of uplift in the landforms. The steepness of rivers, which depends on channels' declivity, is a fraction of uplift rate. Thus, it is expected that if steepness in the longitudinal profile of the river is low, the uplift rate is slight, and if it is high, the uplift rate becomes intense. Concavity index usually depends on bed material; however, erosion efficiency has direct connection with incision power law and its steepness. At the same time, weakness of bed materials, especially alluvial, can boost the rate of erosion efficiency in channels. This latter

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parameter is the volume of sediment, completely removed from the environment after erosion. A function of sedimentary flux, it can be directly related to the tectonic processes as well as bedrock characteristics. If tectonic processes lead to an increase in the landforms' height, they are capable of increasing orographic precipitation in mountainous areas, leading to an increase in sedimentary flux, which in turn boosts erosion efficiency as well. The main purpose of this study is to analyze the effect of active tectonic and erosion on equilibrium profile of the main rivers of Damghan Mountains, based on the Stream Power Law. Both steepness and concavity parameters are affected by a set of lithological, geological, topographic, and erosion factors, all of which are effective for the location of rivers' knick points and are able to provide useful information about the geological and erosion status of the area.

Material and Method

In order to investigate the power incision law, the DEM map with a resolution of 30m was utilized to extract the channels. When extracting the rivers, their flow direction was calculated via D8 algorithm method, which measures the flow path of each pixel, falling on the lower pixel with a lower slope, thus determining the flow directions. In this regard, we first need to create a DEM map with the least inconsistency. This method focuses on extracting central flows in valleys and reducing parallel flows. Hence after extracting the channels, their slope-area logarithmic diagram got plotted. The regression line considered for the logarithmic plot was the power regression, the relation of the river incision power. In this regression, the slope of the regression line is concavity and the intercepting line, the steepness. To obtain information about lithological features of the area that are effective for analysis of both concavity and steepness parameters, the geological map of Damghan and Shahrud was used. The study area is part of the mountainous structure of Eastern Alborz, having several active faults. North Damghan Mountains are located on the southern side of eastern Alborz between 36° 14′0.3″ to 36° 18′ 82″ and 55° 00′ 26″ to 53° 59′ 56″ in north of Iran plateau. There are different outcrops of lithostratigraphic formations from Precambrian to Quaternary in this area. Geologically speaking, the study area is composed of a set of over thrust blocks and nappes. The thrust faults and nappes within piggy back style have pushed eastern Alborz stratigraphy sequences on each other. The folds in the region have a strong connection to thrust structures and nappes. These folds are of different types and sizes, but most of them are inclined and recumbent because of the widespread compressive component in eastern Alborz.

Result and Discussion

The three main rivers of the region, Cheshmeh Ali, Astaneh, and Tepal were studied. All three rivers flow on the colluvium bed in the upstream and alluvial bed in the downstream. Furthermore, all three are affected by faults in some areas. Some, such as Cheshmeh Ali River in the southern part, flows into a fault valley, where the activity of faults along the rivers, both in the resistance and alluvial parts, has uplifted the rivers. These effects can be seen in the high values of steepness index and low values of concavity index. The increase in the stream incision is seen in both the upper and lower section of the rivers due to the activity of faults in the region. However, the steepness is higher in the upstream, which is made of colluvium sediments. While downstream, due to the weakness of alluvial sediments the rate of erosion

efficiency is higher. Therefore the change in the rate of steepness, concavity, and erosion efficiency, in addition to active tectonic, is strongly affected by the channels' bedrock. Each rivers that is faultier also has higher values of the steepness index. Cheshmeh Ali River, part of which is located completely in the faulted valley, has the highest rate of steepness, compared to other rivers. Astaneh River is affected by Astaneh fault in several parts, and the fault has uplifted the river by cutting off the Quaternary sediments. The high values of steepness parameter in this river confirm existence of active tectonic. In its upper part, Tepal River shows high values of steepness, but downstream, where the river flows on agricultural lands, the erosion efficiency rate increases and, in contrast, the steepness rate decreases. This is due to human activities, which exceed the rate of erosion from that of tectonic processes. Therefore, human activities are able to transform the relations between internal and external processes that are effective in changing landforms.

Conclusion

Results show that reaching the equilibrium profile in each river depends on a set of factors, such as erosion, tectonic, and lithology. Presence of a fault in the channel path increases the height and slope of the river channel, leading to further erosion in response to this. Tectonic processes boost the incision capacity of rivers as a result of increasing their channels' slopes, which in turn leads to production of more sediments in the river. Of course, similar to Tepal River, we must consider the role of human activities in increasing the rate of erosion efficiency.

Keywords: Eastern Alborz, Damghan, Active Tectonic, Morphotectonic, SPL Model.

Frequency Distribution Patterns of Precipitable Water in Iran

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Extended Abstract

Introduction
Precipitable Water (PW) is highly variable in space and time, being one of the most important abundant greenhouse gases to play a crucial role in the study of climate change, hydrological cycle, energy budget, and numerical weather prediction. Knowledge about spatial and temporal variability of PW is important for understanding climatic processes along with monitoring drought conditions and desertification processes (Kaufman & Gao, 1992). It is, therefore, necessary to obtain the distribution condition of water vapor in the atmosphere and understand the effects of spatiotemporal variations of PW on regional, meso-micro scales as well as global climate change (Wang, 2013). PW has a very short life cycle in atmosphere. This rapid turnover, accompanied by temperature variations with altitude and geography, distance to sea, evapotranspiration, and moisture advection, causes an irregular PW distribution in the atmosphere, both horizontally and vertically. Thus this study aims at identifying the distribution patterns of PW in Iran and correlate these patterns with elevation and distance to sea.

Materials and Methods
The present research uses MODIS Aqua data **(**MYD05_L2. A V06) and selects the data with spatial resolution of 1 km (Near Infrared)**.** The selected study period covers from 2002/07/04 to 2017/07/25 (5501 days), taken from NASA web site. These data are erroneous in the range between 5% and 10% (Kaufman & Gao, 2003). The spatial resolution of PW data are 1 km and the temporal resolution, twice per day. Afterwards, by using the functions, these data are converted from Level_2(swath data) to Level_3(grid data) and PW values interpolate on sinusoidal grid in 1800×2700 matrix with 1 km spatial resolution and daily temporal resolution. These data have been extracted for pixels within the political boundary of Iran and result in a matrix with 1884080 rows (locations) and 200 columns (PW classes). Then on the matrix' base, frequency distribution is calculated in 1 mm intervals from 0-199 mm for every pixel (1884040×200). Finally, Principal Component Analysis (PCA) is performed, allowing the identification of frequency distribution patterns in Iran. The effects of altitude and distance to

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sea on these patterns are analyzed. The special program is developed and employed in MATLAB software for data analysis.

Results and Discussion

The spatial distribution of atmospheric humidity in Iran is controlled by the altitude, distance to sea, and moisture advection. Based on the results, the mean annual PW of the country is about 12 mm. PW is maximum near the southern and northern coasts of the country, with the highest and lowest PW value observed near the Oman Sea coast (31 mm) and the peak of Damavand (3 mm), respectively. Results from PCA show that 95% of spatial variation of PW can be explained through 4 components. Accordingly, local factors like distance to sea and altitude are the most important ones in spatial distribution of PW. The study of the correlation between distance from the sea and frequency distribution patterns of PW shows the effect of distance and proximity to the sea in the frequency distribution patterns. This is more evident in the first and second components. As expected, up to a distance of approximately 250 kilometers in the first component and 150 kilometers in the second, the amount of PW will gradually decline. From then on, the spatial pattern of PW is affected by altitude and morphology rather than by distance from sea and sea\land breeze. In the third component, due to the formation of a moisture convergence belt at approximately 11 and 4 km, respectively, on the south and north coasts, the amount of atmospheric moisture is maximum. Then from 11 to 66 kilometers due to the Alborz Range, which is a short distance from the Caspian Sea, the amount of PW is minimal. Minimal atmospheric humidity on the southern coast occurs approximately at 250 kilometers away from the sea. In the South Coast, moisture penetrates the country further away from the coast, as it is smoother than the North Coast. Thus, sea moisture enters through the straits of Kahnouj Area into Jazmourian Plain, distinguishing it from its surrounding areas in terms of moisture. Moisture in the Caspian Sea enters the Tarom Valley through Manjil Strait. The spatial distribution of moisture in the western, middle, and eastern Persian Gulf coasts does not have a similar pattern. This difference is because of factors like the dominance of sea-land breeze in the eastern areas of Bushehr and the presence of small firth and bays in the area that increase its atmospheric moisture, in comparison to the surrounding areas. The amount of moisture in the coasts of Oman Sea is clearly different from PW of the Persian Gulf. PW MODIS is also overestimated in places such as near beaches with high temperatures and humidity.

In addition to the altitude and distance to sea, the role of moisture advection should not be ignored. In the coastal region, the variability is caused by high temperature and moisture advection, whereas in areas far from coastline, it is the altitude that causes many spatial differences in moisture distribution.

Conclusion

Although Iran is bounded from the north and south to the sea, atmospheric moisture is very low in the country. According to the results from this paper, minimum and maximum difference of PW is about 27 mm. Thus, in a region above 3000 m from the sea level, PW falls below 6 mm, and the coasts of Oman Sea are above 26 mm, 60% of the time. This means that in spite of the great sources of water both in the south and the north, Iran’s atmosphere suffers from poor moisture. Topography acts as a barrier for moisture to enter inland regions from both north and

south seas. Inland, the altitude plays a crucial role for frequency distribution of PW, while in the coastal regions, both moisture advection and temperature are culprits. In this way, moisture advection is an important factor to justify spatiotemporal variations of PW in Iran well. And it is this parameter that affects water budget.

Keywords: ***Precipitable Water, Principal Component Analysis, Frequency Distribution, MODIS, Iran.***

Comparing the Performance of SARIMA and Holt-Winters Time Series Models With Artificial Intelligence Methods in Dust Storms Forecasting (Case Study: Sistan and Baluchestan Province)

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Extended Abstract

Introduction
The impact of dust phenomenon in Iran is so great that it has involved more than half of the country's provinces with problems and limitations one way or another. In addition to environmental impacts, it has disrupted implementing sustainable national development plans, having already brought about many negative consequences. Increased number of dust storms in recent years in the east and southeast of the country, especially in Sistan and Baluchestan Province, and consequently the decrease of air quality in these areas, has doubled the importance of forecasting this phenomenon. On the other hand, most domestic studies in this field are related to the process of small-scale dust phenomena, synoptic studies, and its satellites. Therefore, considering that this phenomenon has had adverse effects and negative consequences on social, economic, and healthcare aspects of human life, it is necessary to study, forecast, and measure its correlation with climate variations.

Materials and Methods
This study aimed at comparing the performance of SARIMA and Holt-Winters time series models with artificial intelligence methods, including neural networks based on Radial Base

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Functions (RBF) and Adaptive Neural-Fuzzy Inference System (ANFIS) to forecast the Frequency of Dust Storm Days (FDSD) in the next season. For this purpose, it used World Meteorological Organization codes as well as hourly dust data from five synoptic stations in Sistan and Baluchestan province with a statistical period of 25 years (1990-2014). The observations of meteorological phenomena were recorded once every three hours, making it eight times a day in total. In these observations, the visual phenomena of the climate were defined according to the guidelines of the World Meteorological Organization in 100 codes (00-99), in which 11 codes were used to record and report the phenomenon of dust in different meteorological stations. Following the time series of days with dust storms, the FDSD index was forecasted, using four methods SARIMA, Holt-Winters, RBF, and ANFIS.

Results and Discussion

According to the time series' results, the FDSD index in Saravan, Khash, Iranshahr, and Zahedan stations displayed relatively small variations that were scattered throughout the time series, but with more dusty days at Zabol station, the variations' scattering decreased and its intensity increased. Also, the peak values of dust were concentrated in close vicinity of one another, indicating the occurrence of successive dust storms at this station from 2000 onwards. As can be seen in ACF and PACF diagrams of the studied stations, significant time intervals indicate a correlation between the time values that make it possible to model and forecast the future values (next season) of the FDSD index for all five stations studied. The range of attraction change and moving average got determined according to partial autocorrelation and autocorrelation functions and using appropriate evaluation criteria, the best time series model was extracted for each station. In the Dickey-Fuller test, the significance level was considered to be P-Value < 0.05. According to this test, only the time series of Zabol Station was unstable, confirming the results of ACF and PACF diagrams of the studied stations. Results showed that ANFIS Method performed better than other methods in all studied stations. Thus, in this method the evaluation criteria ranged from 0.72 to 0.95 for R, from 0.57 to 0.51 for RMSE, from 0.42 to 0.40 for MAE, and from 0.71 to 0.96 for NS. Also, the average frequency of days with dust storms on a seasonal scale varied from 1.06 to 7.11, allowing forecasting accuracy of all methods to increase as the FDSD index mounted. In SARIMA time series model, the correlation coefficient (R) between the observed and forecasted values of the FDSD index rose from 0.64 to 0.79. As for Holt-Winters, RBF, and ANFIS methods, this value varied between 0.70 and 0.87, 0.69 and 0.92, and 0.72 and 0.95, respectively. Moreover, based on the results of the observed and forecasted values, the greater the FDSD index in the studied stations (progress from Saravan to Zabol Station), the more the compatibility of observed and forecasted values in all methods (time series models and artificial intelligence methods) with Semi-constructor of the first quarter. The results from the Z test also proved the assumption that stated that zero-based on the mean equal of the time series of FDSD index' observed and forecasted values were not rejected in none of the studied stations, according to ANFIS and RBF methods at 1% and SARIMA and Holt-Winters time series models at 5% error level.

Conclusion

The results showed that as the frequency of days with dust storms in Saravan and Khash stations got less, the Holt-Winters time series model showed an almost similar and better performance

than the RBF method. This indicates this model's high capability to forecast low values of FDSD index. The results also showed that the SARIMA time series model, compared to other forecasting methods, did not show a high ability to forecast FDSD index at any of the studied stations. Furthermore, despite the low frequency of days with dust storms at Iranshahr station, compared to Zahedan station, all FDSD index forecasting methods had a better performance and higher accurately than Zahedan station, based on the evaluation criteria, which can be searched due to the presence of a complete series without FDSD index termination at Iranshahr station. The results of this study can be useful for forecasting and managing the consequences of dust storms in the studied areas. On the other hand, when forecasting the FDSD index in Sistan and Baluchestan province, the optimal predictor model has been complex. For all of the stations studied, the model that used three or four steps of the predictive delay was recognized as the best predictor model. Therefore, particles leftover from previous storms could be an important cause for the impact of the last few seasons' dust storms on the formation of new ones in the coming seasons.

Keywords: Dust, ACF and PACF, Neural Networks, Critical Areas of Dust, Time Series Analysis.

Estimating of Biomass and Wheat Dry-Farming Using Landsat OLI Imagery

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Extended Abstract

Introduction
With a dominant arid to semiarid climate, Iran enjoys a diverse agro-ecosystem. Despite the country's enormous territorial span, its agricultural lands encompass areas with limited precipitation and ground water resources. Dry-farming is a common practice in Iran, which faces certain challenges in areas like pre-harvest estimation of straw and crop yields. Sustainable agricultural activities require precise information on crops, which can be obtained from remote sensing data. This study proposes a remote sensing vegetation index-based phenology modeling to estimate the straw and crop yield of dry-farmed wheat via Landsat OLI imagery in Gilangharb of Kermanshah province in Iran.

Materials and Methods
A satellite-based straw and crop yield estimation method was developed for dry-farmed wheat, using Landsat OLI imagery. Field data were measured in metric ton per hectare through farm-based measurements of the net weight of wheat crop and straw, produced in dry-farming. The data were obtained through direct field surveys during the harvesting time. Using GPS, the study managed to single out the wheat farms from their surrounding farmlands. It also used time series of Landsat-8 satellite imagery from mid-February to late-May in the study years (2014-2018). Once the images got pre-processed, they were classified via a multi-temporal image classification procedure, where Normalized Difference Vegetation Index (NDVI) and Green Leaf Area Index (GLAI) were adapted as vegetation indices for wheat phenology modeling to be linked with the measured straw and crop yields. Annual phenology curves of both indices for each farm were statistically investigated, using the geometric characteristics of the phenology curve. The statistical relation between phenology curves and straw and crop yield was then

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calculated. In order to evaluate the results accuracy, field-measured data on straw and crop yield were compared with the obtained results.

Results and Discussion

Kappa coefficient and overall accuracy were calculated using classification error matrix in order to evaluate the overall accuracy of image classification. Results accuracy was assessed, using the area of the curve of phenology diagrams for both vegetation indices of all wheat farms as well as the regression relations and coefficient of determination (R2) between indices and the measured wheat crop and straw. From the five phonological growth stages of wheat, namely germination/emergence, tillage, stem elongation, boot, heading/flowering, and grain-fill/ripening, the penultimate stage (flowering) had the highest correlation with the wheat crop and straw. The study results revealed that green leaf area index (GLAI) had a higher coefficient of determination than NDVI. GLAI represents the main part of the photosynthesis in plants (leaf), the main factor for growth process of wheat. Hence, it had closer association with the plant's production process. Therefore, GLAI outperformed NDVI in wheat phenology modeling for crop and straw estimation, though both indices were employed in the modeling since the main goal of this study was to obtain a more precise multivariate regression correlation.

Conclusion

Using a multivariate regression analysis along with both GLAI and NDVI, the straw and crop yield of dry-farmed wheat was estimated with a high coefficient of determination (about 0.8). This coefficient was slightly higher for straw (R2=0.865) than wheat crop. Results of phenology investigation showed the model’s ability to estimate the wheat yield. Furthermore, it was revealed that out of the five phonological growth stages of wheat, the flowering stage (R2=0.65) had the highest correlation coefficient.

Keywords: Multivariate regression, wheat crop and straw estimation, phonological stages, GLAI, NDVI, Landsat-OLI.

Measurement and Sociological Assessment of the Varamin City's Resilience against Climate Change

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Extended Abstract

Introduction
Over the last decades, increased urbanization and lack of accurate and comprehensive planning for develop and rapid population growth have caused cities to face many challenges. Urban sprawl, which began in developed countries around 1950, is currently experienced in almost all countries. Many studies on the impacts of urban sprawl indicate the emergence of harmful effects from this phenomenon, one of the most important examples of which that has an environmental nature is climate change. Most urban settlements are prone to future shocks and tensions due to climate change, lack of energy, and global population growth. Urban managers and planners' response to these shocks and the course of action that municipalities should take in order to adapt to upcoming accidents and dangers are now discussed in "resilient cities" topic. A good number of cities have not yet addressed climate risks due to lack of relevant city policies and action plans, outmoded regulations on urban planning, lack of capacity to respond to climate disasters, and no public awareness. The area of Urban Climate Resilience Practice represents the conjunction of WRI Ross Center for Sustainable Cities and World Resources Institute's Climate Resilience Practice. As for Iran, urbanization trends have accelerated during last decades by a high rate of rural-urban migration along with rapid socio-economic and political changes, leading to unbalanced urban growth in the country. Since resilience refers to a system's ability to return to its natural conditions following an accident, the purpose of the present study is to test and evaluate the level of resilience of Varamin City in the face of climate change from its citizens' viewpoint.

Materials and Methodology
The present research used two types of data, the first being climate components, gathered from Varamin weather station (annual average rainfall, temperature, etc.), and the second, involving components relevant to urban sprawl, such as urban area, population density, and urban

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population. These parameters were obtained from questionnaires, filled out by a total of 393 citizens of Varamin, making this study a descriptive analytical one. The 35-item researcher-made questionnaire that served as the research tool for data collection was based on previous studies and contained appropriate items to test each of the components. In order to validate the research population, the questionnaire was investigated and reviewed by professors and experts in multiple steps and both its face and content validity got confirmed. For assessing the questionnaires' reliability, at first, 30 copies of the questionnaire were answered by Varamin citizens in a preliminary research. The obtained information were inserted into SPSS 21 and each response was assigned a score of 0-5. Following this analysis, the questionnaire reliability got estimated by means of Cronbach's alpha, giving a score of 0.89, designed based on the environmental, socio-economic, infrastructure, and institutional components. Also SPSS 21 helped analyzing and prioritizing both descriptive and inferential analytical statistics for each components' resilience, whose indices got calculated by the same software program as well. For so doing, it first used one sample T-test and then prioritized them via Friedman test.

Results and Discussion

Today, the correlation between human societies and their natural environment is strongly affected by urbanization and urban development. Cities could be regarded as ecological units to be studied within the framework of a data-retrieval system. That means in order to meet various needs of citizens, the city inevitably needs to provide massive data in key inputs, the most important of which include energy, food, and water.

Results from measuring resilience of Varamin City with an emphasis on climatic aspects showed that from the citizens' viewpoint, the resilience was 2.15, falling below the desirable average level. This by itself indicates that the citizens consider Varamin vulnerable to climate hazards. Results from investigating resilience components of Varamin City showed that the environmental component and its indices were lower than the average level, too, and –according to the citizens—intensified drought and changes in temperature had the most negative effects on the environmental condition of resilience in Varamin City. Moreover, according to the citizens, Varamin City is vulnerable to increased temperature and drought, both of which ought to be taken care of, if urban resilience is to be boosted. Meanwhile, the citizens believed that socio-economic and infrastructure components had higher resilience levels, compared to the environmental and institutional ones. The socioeconomic component and most of its indices were above the average level. So, according to the citizens, helping the citizens in case of critical situations and kinship are really significant for socioeconomic resilience of Varamin City when faced with climate changes. Results from investigation of infrastructural component showed that this component and most of its indices were below the average level. Therefore, it can be stated that this city is not in a good condition in terms of its infrastructure and is vulnerable in this regard. Furthermore, according to the citizens, the index of "access to health centers" was the most significant infrastructural index. Investigating the resilience level of the institutional component showed that all indices of the institutional component fell short of the average. Furthermore, Friedman Test scores indicated that from the citizens' viewpoint, the municipal services in creating green space along with their satisfaction from the performance of the organizations, in charge of informing the people for facing hazards, had the highest

significance in the institutional resilience of Varamin City. Although apart from the socioeconomic components, other components in the present study were lower than the average level since the environmental and institutional components were the least resilient components, strengthening them should be top in priorities of urban development plans of Varamin City.

Conclusion

Since climate change and its effects are increasing more than before in human societies, especially in urban communities, it is very effective and essential to investigate the indices and components of resilience, evaluate them when urban communities face future climate crises, and take preventive measures. Furthermore, the increase of general knowledge regarding climate change motivates people to investigate the effects of this issue even more. Therefore, the serious cooperation of the government, local entities, educational organizations, municipalities, and the media in increasing the citizens' awareness will make the citizens respond significantly to reduce and adapt to the consequences of climate change through their participation.

Keywords: resilience, climate changes, sustainable development, compatibility, Varamin.

Locating Road Meteorological Stations Using Analytical Hierarchy Process Method (Case Study: Alborz Mountain Roads)

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Extended Abstract

Introduction
Roads are part of civilizations' development. Not only do they support economic activities, but they are the foundation of new life. However, it is quite unfortunate to note that in the last decade due to low driving culture, non-standard vehicles and roads, environmental factors, and increasing traffic volume, number of road accidents have increased dramatically. Four factors of human, vehicle, road, and environment are always responsible for occurrence of accidents. Among these environmental and climatic factors that happen due to particular geographical conditions of Iran and its mountainous nature, along with other factors play a significant role in accidents. Major road meteorological tasks for both land and rail transportation are one of the most important issues at a national level. These involve continuously preparing statistical data and information; changing and evolving meteorological elements in the area of roads covered by the relevant station; issuing specific meteorological forecasts along the route in relation to wind intensity and speed, thunderstorms, and occurrence of destructive phenomena; and publication of notices and warnings in the event of dangerous weather phenomena on the way, intense winds on various stairs, and phenomena that are effective in reducing the vision. The aim of this study is to locate the meteorological stations of the Alborz Mountains axes (Chalus and Haraz) using the Location-Allocation method.

Materials and Methods
The study was conducted in the mountainous roads of Alborz (Chalus Axis and Haraz axis). The criteria used to locate road meteorological stations pertained to the climate (rainfall above 30 mm, avalanche, snow cover, fog, and minimum and maximum temperature of -10 and 30 degrees Celsius), geomorphological aspects (rock fall, landslides, and active faults), traffic

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(accidental points and environmental criteria), and economic security (traffic). Then, using the Analytical Hierarchy Process (AHP) method, based on the determination of variable comparison matrix and weighting each criterion, the final prioritization map got prepared in accordance with the final weight. Afterwards, based on the Location-Allocation Analysis, the proposed meteorological stations on the mountainous axes of Alborz were determined.

Results and Discussion

Three meteorological stations of Karaj (from Karaj to km 43), Siah Bisheh (km 43 to 110), and Nowshahr (110 km onwards) reflect the climatic conditions of each section. The number of days recorded for fog occurrence at Siah Bisheh Station was approximately 844 days in a decade-long duration, while Nowshahr and Karaj Stations had 70 and 50 foggy days, respectively. Therefore, about 43 to 110 km of the road had the highest probability of foggy days, according to the statistics of Siah Bisheh Station.

As for the case of frost, 60 to 100 km of the road, from the city of Karaj (middle part of the axis) was riskier than the rest. From the beginning of the axis to 60 km, approximately the area between Vali-Abad and Marzanabad, the risk of frost was moderate. In other parts of the axis, the intensity of frost was either low or very low.

Chalus Axis in Mazandaran Province, from approximately the area of Vali-Abad village to Chalus City itself, included high and very high risks of rainfall above 30 mm, whereas in Alborz Province it experienced low rainfall risk conditions.

Due to the minimum temperature threshold of the middle part of Chalus Axis, involving two provinces of Alborz and Mazandaran, it was in moderate danger. This part of the axis included Nesa, Gachsar, Siah Bisheh, and Harijan. Other parts of the axis belonged to the low risk class. Yet, due to the maximum temperature threshold in Chalus Axis, the hazardous conditions of the axis were low in Alborz Province and very low in Mazandaran Province.

Examining the average snow cover by the desired months in this study, it can be seen that the middle parts of the Chalus Axis experienced the highest frequency of snowfall. Come the warmer months of the year and a gradual trend of snowmelt could be observed.

In terms of avalanche risk, the area of Asara village had a moderate risk, while the central sections, from Garmab village to Zangoleh Bridge, fell under high and very high classes. From the Siah Bisheh Area until the end of Chalus Axis, the avalanche fell to the low-lying class.

The 74 km, 78 km, 82 km, 84-85 km, and 88-89 km points from the beginning of the axis had been reported to be affected by landslide phenomenon. In terms of point density, at 78 km to Chalus in Mazandaran Province had the highest amount.

The maximum number of accidents took place either at 17-20 km or 41 km from the start of the axis in sunny weather; at 62 km in cloudy weather; at 40 km or 70 km during the rainfall; at 40 km, 60 km; at 62 km in snowy weather; and at 60 km, 62 km, and 65 km during the foggy weather.

The importance of each criterion and sub-criterion got determined in accordance with library studies, installation guidelines for road meteorological stations, and expert opinions. The uncertainty coefficient was also 0.6, less than the defined 0.1. Based on this result, the weighting process was approved. According to global standards as well as conducted studies, the distance between meteorological stations on the road varied between 30 and 50 square

kilometers. In general, each meteorological station could cover an area of about 30 km.

Then, using AHP Method, the final weight of climatic, geomorphological, traffic, and economic-security criteria and sub-criteria in Haraz and Chalus Axis were determined. After prioritizing the new stations in terms of need in the previous step, through Location-Allocation Analysis as well as examination of optimal distances of the axis from the highway, fuel stations, surveillance cameras, and villages around the axis, the final stations were introduced in a priority-oriented fashion.

Results

Due to the importance of optimal development of road meteorological network, which reduces road casualties, damages the surrounding environment, and brings about economic savings, the optimal location on Chalus and Haraz Axis was examined. Results showed that the required stations on Chalus Road are in the area of Kiasar, Marzan Abad, Khargoosh Darreh, and Vali Abad and inside Haraz Road in Polur, Abali, Rahdari, and Rineh.

Keywords: Analytical Hierarchy process, Alborz mountain roads, climate risk, Traffic Criterion, geomorphological Criterion.

Monitoring Heavy Metals from Dust Storms in Wheat Agronomic Ecosystem Soils in Southern Fars Province

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Extended Abstract

Introduction
Heavy metals in dust particles play an important role in contamination of agricultural soils, being one of the most dangerous pollutants in the environment due to their bioaccumulation power. In other words, they are able to accumulate inside the bodies of living organisms and increase their concentration with greater exposure to pollutants. Heavy metals are generally referred to as a group of elements with a specific gravity, greater than 6 g/cm^3, more than 50 g of atomic weight. The most important heavy metals, important for environmental protection, include cadmium, arsenic, cobalt, vanadium, zinc, mercury, iron, manganese, nickel, lead, chromium, and copper which owing to their non-biodegradability in the nature as well as long life span, are considered important pollutants in the environment. Moreover, pollution of agricultural lands with metals through chemical activities like sewage sludge, chemical fertilizers, and industrial wastewater along with the deposition of dry and wet dust particles from dust storm phenomenon can be seen as one of the most important sources of pollutants for wheat agronomic ecosystems to heavy metals. Pollution with heavy metals from dust storms is considered a serious problem due to toxicity, degradability, and cumulatively. Following the deposition of dust particles, contaminated with heavy metals on crop fields, the contaminants are combined with the soil solution. As the plants absorb the heavy metals in this way, they pave the road for them to get transferred to the food chain. As a result, deposition of dust particles with heavy metals in the soil of wheat agro ecosystems can endanger human health and the present research aims at identifying the heavy metals content in wheat fields, which is the first step to reduce this health risk.

Materials and Methods
This study obtained the data concerning the dust storms in a 16-year period (2000-2015), belonging to Larestan, Jahrom, Darab, and Fasa Stations, from the Meteorological Organization. It then analyzed the frequency of dust storms on both a seasonal and an annual scale. Next, the dust particle entry pathway to the study area on May 12, 2018 was performed, using HYSPLIT

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model. This was followed by obtaining soil samples from wheat farms in Larestan, Fasa, Darab, and Jahrom. Four wheat ecosystems got identified in each study area and soil sampling was performed from a depth of 1 cm at an area of 400 cm^2 in each ecosystem. The soil sampling was divided into two stages: before and after the dust storm. Pre-dust storm sampling took place in December and March, and post-dust storm one happened in May and June. Soil samples were transferred to the laboratory, where their concentration of lead, cadmium, and nickel was measured via flame atomic absorption spectrometry. Finally, the amounts of heavy metals in the soil samples were evaluated by the I_{geo} index.

Results and Discussion

The maximum frequency of dust storms in the southern part of Fars Province is due in warm months, especially in the spring, with an average of 18 dust storms per season. The minimum occurrence rate of this environmental phenomenon belongs to the cold months, especially in the autumn, which occurs less than once a season. In addition, among the stations in the study area, Fasa Station usually faces the maximum annual dust storms with 42 occurrences, with Jahrom, Darab, and Lar Stations in the next ranks with 39, 25, and 19 storms per year, respectively. The path of dust particles entering the study area on May 12, 2018 was tracked, using HYSPLIT Model in a backward method. The results showed that deployment of thermal low-pressure in the Persian Gulf had destabilized the atmosphere and Shamal winds moved through the deserts of Iraq and Saudi Arabia to the Persian Gulf, both contributing to the transportation of a massive amount of dust particles into the southern provinces of Iran. Moreover, the results showed that concentrations of lead and cadmium in the soil of wheat agronomic ecosystems of Fars Province increased under the influence of dust storms, whereas the concentration of nickel remained unchanged. The highest concentrations of heavy metals were in Darab and Lar ecosystems and the lowest in Jahrom and Fasa. The mean comparison test showed a significant difference between the concentrations of heavy metals in agricultural ecosystems in southern Fars province before and after the dust storm at 0.05 and 0.01 levels. Also, dust storms increased the heavy metals in the soil of wheat ecosystem. Furthermore, the land pollution standard showed that in the agricultural wheat ecosystems of Darab, the concentration of all metals was higher than the global limit, being in the moderate to severe pollution category.

This study investigated the effect of desert dust on heavy metal concentration in soil ecosystems, measuring their concentrations before and after the occurrence of dust and comparing their differences with statistical tests. It showed that the concentration of lead and cadmium in the soil of wheat agronomic ecosystems increased under the influence of dust storms, while that of nickel remained unchanged.

Conclusion

In addition to combustion sources, industries and factories, traffic, and the use of fertilizers and municipal wastewater, desert dust particles contribute to air pollution, too. Higher concentrations of heavy metals in agricultural soil can affect health and damage environmental ecosystems and organisms, especially humans, the chief consumers of these agricultural soil products. Deposition of dust particles, caused by dust storms in cultivated wheat soils, results in increased concentrations of heavy metals in the soil and its uptake by plant roots and movement to the crops put human health in jeopardy. Because wheat is one of the most consumed morsels

in human diet and given that movement of toxic substances as well as heavy metals through soil, roots, and plants causes them to accumulate in wheat, in order to achieve world-class quality and health products, some solutions must be offered to reduce heavy metal concentrations in consumer products. Thus, this study's results could and should be made available to not only planners but also agricultural and health experts.

Keywords: Atomic absorption, Fars Province, HYSPLIT models, I_{geo} index, Lead.

Exploring the Concept of Scale and its Explanation in Geomorphology

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Extended Abstract

Introduction

There are several fundamental issues in geomorphology, one example of which is scale. There is a special correlation between landscapes, on the one hand, and their forms' components, on the other. This indicates a kind of scale continuity. Such rules and scale relations prevail not only at perspective level but also at the level of land forms, and thanks to the complexities of this concept in geomorphic studies, they have received less attention. However, accuracy of many geomorphic concepts is related to such concepts. Usually in scale geographic literature, a simple ratio is defined that is often used to represent the extent to which a phenomenon is reduced to its actual ratio in the maps, yet truth be told scale in geomorphology involves a broader concept: any subject that expresses a ratio lies within the conceptual realm of scale, though few geomorphologists have pointed this important issue out. Scale plays a vital role in geomorphology, both in the realm of performance and in the field of epistemology. For example, in the field of soil geology, particles' chemical processes alter as the dimension reduces to two microns. Also, the properties of their elements generally change. Hence, in the geography of clays, which can only express the size of each substance (not their sex), chemical performance is extra important, since many vital and mineral reactions in the soil depend only on the size of the elements, not the elements themselves.
Therefore, in statistical analysis, relation measurement, i.e., correlation techniques, is a concept of scale, because when you write a linear formula or other form of correlation, the ratio between the two variables is actually defined. Therefore, scale is one of the fundamental issues that, from a theoretical point of view, leads to the formation of other concepts, such as universality, fractal, river networks, geo-allometry, specific scale, etc.

Materials and Methods

In order to achieve an advanced concept of scale in geomorphology, following a relatively extensive search for books and articles in this field, several geomorphological pioneers, who used this concept in the field of scale in their works with a special theoretical innovation got selected. They included:

- John Charles Doornkamp, geographer from the University of Nottingham, England
- John Tilton Hack, American geologist and geomorphologist
- Evans, geomermologist from Durham University in UK and a graduate of York

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University, Canada

- Donald Lawson Turcotte, geologist from Cornell University, USA
- Benot Mendelobert, French-American mathematician from Yale University
- Dave Rosgon, hydrologist and geomorphologist from the Universities of Nevada, Montana and Colorado
- Leila Goli Mokhtari, geomorphologist from Sabzevar University, Iran

Afterwards, by selecting the books and writings of these researchers in this field, we began to study, separate, and classify their opinions, removing their repetitive content, at times shared by all of them in the process. In the final stage, we began to extract newly-found writings, specific to each of them, summarizing and analyzing their content as an opinion.

Results and Discussion

In the first step of this research, the most important result, achieved in terms of time, was the way of developments and the volume of work that has been done in this field. Review of the researchers' scientific papers showed that studies on the subject of scale of the trend have increased in the last 30 years with theoretical innovations in applying this concept becoming increasingly complex.

The second step, wherein thematic classification of the seven researchers' opinions was of high account, dealt with semantic difference of the subject of scale. Although all these writings could be regarded as concerning the scale, the novelty of the works by these seven researchers was that they presented completely different and original interpretations and concepts, e.g. the specific scale of Evans' innovation, invariance scale of Turcotte, or geoallometry of Golemokhtari's theoretical innovations. With these initial achievements, the views of these seven researchers were then described and analyzed.

Conclusion

Scale in general is called the actual size of a phenomenon in geography, usually shown as a deduction or line. Fraction in numerical scales can be expressed with a fixed face and multiple denominators, e.g. in maps (1:50000 or 1:250000) and so on. Another pattern of scale display is expressed by showing a fraction with a different face and a fixed denominator, is called gradient, such as two in a thousand or five in a thousand, etc. Finally, ratio in geometry is expressed as an angle and is called a tangent.

During the last three decades, geomorphologists and related sciences have been able to apply some of the most complex concepts of scale in their works, with specific titles. These concepts include Universality Scaling, which is due to hacking, or the concept of "specific" that can be found in Evans' work. Turcotte defines the concept of invariance scale (meta-scale), whereas Mendelobert's work on fractional scale and Rosgon's on the thematic scale along with Goli Mokhtari, can be considered the creators and determinants of scale in geoallometry.

Finally, it can be said that each researcher has presented different concepts in the discussion of scale but the common ground among these researchers is their deeper understanding of the importance of earth and the phenomena of geomorphology. It must be confessed that the depth of their understanding of geomorphology has played a leading role in their theoretical innovation.

Keywords: Scale, Invariance scale, specific scale, Geoallometry.

Vector Techniques Application in Line with Dust Modeling and Homogeneous Classification of Areas in Iran

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Extended Abstract

Introduction
Mineral dust is an aerosol, mostly affecting radiation budget, temperature change, cloud formation, convection, and precipitation, both directly and indirectly. During the two recent decades, new sensors and models have become available, allowing new research activities on dust. Important studies considered Atmospheric Optical Depth (AOD) as the key parameter for remote sensing and modeling of dust. The available model with the help of satellite and ground-station datasets have been used to detect and characterize mineral dust phenomenon in affected regions and dust sources. Nonetheless, regional classification over entire Iran, using remote sensing parameters, is still lacking.

Materials and Methods
The present study aims at modelling and detecting homogeneous areas of high dust concentration in Iran, using dust AOD at 550 nm from the MODIS satellite Aqua and Terra sensors (2003-2012) with a spatial resolution of 0.125°×0.125° or about 14 km^2.

Among vector techniques, *S-mode* application, as a Principal Component Analysis (PCA) or an example of Empirical Orthogonal Functions (EOFs), is the most applicable and controversial method of classification for doing so. The *S-mode* analysis was applied on a matrix, made of satellite observations at regularly spaced grid points of daily AOD values for ten years (2003-2012). The *S-mode* analysis was applied to identify the geographycal distribution of high dust concentrations. PCA of the $n \times m$ matrix was utilized and the scree test and North's rule were used to cut-off the statistically relevant components to be kept. Finally, in order to determine the best theoretical representation of the data, physical relations got embedded within the input matrix. Also to localize the territory to simpler structures, specific modes of the residual components got rotated by varimax. Varimax rotation means that each component had a few large loadings and many small loadings. This helps in the process of interpretation in case the results are prone to high values of the explained variance. The rotated patterns, however, illustrate simpler, more interpretable, and rational structures of mineral dust as principal modes. Identification of sub-regions and extreme dust loading was performed, using dust AOD values, assuming arbitrary thresholds of 87% and 95%, respectively. Therefore, the first threshold was

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used to determine sub-regions. Consequently, the regions would have zero overlapping. The second threshold helped extracting the days with extreme AODs of each region. Herein, the Kolmogorov-Smirnov (K-S) test was used to infer whether the regional mean time series PCs of each different sub-region were statistically different or not.

Results and Discussion

The spatial map-patterns of dust, amounting to 91% of AOD variability, had been divided into six subregions on Iran that were the major centers, affected by the dust. All of the sub-regions coincided with regional map-patterns, depending on the distance and proximity to dust sources around the territory. Therefore, overlapping of identified dust areas related to dust extremities in each of Iran's regions showed that the dominant dust patterns of Iran were under the infuence of expansion and growth of dust extremities. The geographical location of source areas and the special dynamic conditions over mid-eastern atmosphere of Iran have been influenced by severe storms originating from the Karakum Desert. The northeast region is affected by the dust plume, from the Karakum Desert to Tabas Desert in the southeast of Kavir Desert. These results showed that ground-based station studies, albeit long-term, had not been able to detect the northeast region as a distinctive region under infuence by southward dust plume. The same was true for the Central plateau, East and Southeast regions. In return, more focus was directed at the role of 120-day winds as a main cause of dust transport. Considering the mentioned reasons, previous studies had not divided the borderline regions across Iran. Meanwhile, weakness and intensity of dust-affected areas showed that the multiplicity and adjacency of dust flow to southeastern and eastern parts of the country were different, playing a decisive role in the formation of east and southeast subregions. The shortcoming were observed for west-northwest and southwest regions, too. In a case study (on horizontal visibility), not only were the researchers capable of distinguishing the dusty subregions because of limited observations in the interested area, but also could not analyze the identified subregions, based on corresponding seasolality and extremities, identified by 95% and 87% in each region, respectively. The detected extremes showed that the identified sub-regions were a function of volume, growth, and expansion of dust particles, originated from the dust source regions across the Middle East and southwest Asia. Finally, the classification techniques showed that technical conversion of a dynamic phenomenon, like dust, into simpler and more meaningful physical structures geographically revealed a simple and interpretable understanding of dust distribution inside the territory of Iran. Morever, the use of remotely-sensed data utilized in the present study highligted the sub-regional distribution of dust over Iran, neglected by previous studies that provided a description of a dynamic process that was complementary to the ground-based observation analisys. In some cases, a day event only based on ground-based observations may have had a high dust AOD with very horizontal visibility, capable of being ignored due to the height of the dust layer. Therefore, the used technique integrated the knowlegde of dust based on grounded-measurement, providing a large scale view of dust advection and diffusion.

Conclusion

The study results showed that extraordinary dry conditions inside Iran, combined with outside dusty sources, had made the country to be influenced by high mineral dust aerosols. In addition to domestic sources of dust, the study highlighted that the mineral dust conditions in Iran were

influenced by several arid and semi-arid sources beyond its boundaries acting as dust sources. The subregions that form the spatial patterns of dust distribution in a six-distinct region of northeast, west-northwest, southeast, southwest, central, and east Iran were affected by high dust aerosol optical depth (AOD). They were major centers of activity and high gradient areas (regions affected by dust) that followed a trend-distinctive seasonality. This managed to illustrate identified sub-regions's seasonalities and regional extremes by remotely-sensed data of atmospheric optical depth. The study results demonstrated that dominant spatial dust patterns of Iran were functions of growth and expansion of dust extremes from source regions in the Middle East and southwest Asia. As a result, the present study showed that technical conversion of a dynamic phenomenon, such as dust, to simpler structures paved the way towards a geographical interpretation of dust distribution.

Keywords: Dust, Iran, Principal Component Analysis (PCA), Zoning.